variations, perhaps even adaptations, were the result of extrinsic factors acting upon the organism, and that these variations or adaptations were increased and improved by natural selection. This is, I believe, the only ground which is at present tenable, and it is but another testimony to the greatness of that man of men, that, after exploring for a score of years all the ins and outs of pure selection and pure adaptation, men are now coming back to the position outlined and unswervingly maintained by him.

Finally, we ought not to suppose that we have already reached a satisfactory solution of the evolution problem, or are, indeed, near such a solution. "We must not conceal from ourselves the fact," says Roux, "that the causal investigation of organism is one of the most difficult, if not the most difficult, problem which the human intellect has attempted to solve, and that this investigation, like every causal science, can never reach completeness, since every new cause ascertained only gives rise to fresh questions concerning the cause of this cause."

The Factors of Organic Evolution from a Botanical Standpoint.

By Prof. L. H. Bailey.

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THE SURVIVAL OF THE UNLIKE.

We all agree that there has been and is evolution ; but we probably all disagree as to the exact agencies and forces which have been and are responsible for it. The subject of the agencies and vehicles of evolution has been gone over repeatedly and carefully for the animal creation, but there is comparatively little similar research and speculation for the plant creation. This deficiency upon the plant side is my excuse for calling your attention, in a popular way, to a few suggestions respecting the continuing creation of the vegetable world, and to a somewhat discursive consideration of a number of illustrations of the methods of advance of plant types.

1. *Nature of the Divergence of the Plant and Animal.*

It is self-evident that the development of life upon our planet has taken place along two divergent lines. These lines originated at a common point. This common life-plasma was probably at first more animal-like than plant-like. The stage in which this life-plasma first began to assume plant-like functions is closely and possibly exactly preserved to us in that great class of organisms which are known as mycetozoa when studied by zoölogists and as myxomycetes when studied by botanists. At one stage of their existence, these organisms are amœba-like, that is, animal-like, but at another stage they are sporiferous or plant like. The initial divergencies in organisms were no doubt concerned chiefly in the methods of appropriating food, the animal-like organisms apprehending their food at a more or less definite point, and the plant-like organisms absorbing food throughout the greater or even the entire part of their periphery. It is not my purpose to trace the particular steps or methods of these divergencies, but to call your attention to what I believe to be a fundamental distinction between the two lines of development, and one which I do not remember to have seen stated in the exact form in which it lies in my mind.

Both lines probably started out with a more or less well-marked circular arrangement of the parts or organs. This was consequent upon the peripheral arrangement of the new cells in the development of the multicellular organism from the unicellular one. A long line of animal life developed in obedience to this peripheral or rotate type of organization, ending in the echinoderms and some of the mollusks. This line long ago reached its zenith. No line of descent can be traced from them, according to Cope. The progressive and regnant type of animal life appeared in the vermes or true worms, forms which are characterized by a two-sided or bilateral, and therefore more or less longitudinal, structure. The animal-like organisms were strongly developed in the power of locomotion, and it is easy to see that the rotate or centrifugal construction would place the organism at a comparative disadvantage, because its seat of sensation is farthest removed from the external stimuli. But the worm-like organisms, "being longitudinal and bilateral," writes Cope, "one extremity becomes differentiated by first contact with the environment." In other words, the animal type has shown a cephalic, or head-forming, evolution in consequence of the bilateralism of structure. The individual has become concentrated. Out of this worm-form type, therefore, all the higher ranges of zoötypic evolution have sprung, and one is almost tempted to read a literal truth into David's lamentation that "I am a worm and no man."

If, now, we turn to plants we find the rotate or peripheral arrangement of parts emphasized in all the higher ranges of forms. The most marked bilateralism in the plant world is amongst the bacteria, desmids, and the like, in which locomotion is markedly developed; and these are also amongst the lowest plant types. But plants soon became attached to the earth, or, as Cope terms them, they are "earth parasites." They therefore found it to their advantage to reach out in every direction from their support in the search for food. Whilst the centrifugal arrangement has strongly tended to disappear in the animal creation, it has tended with equal strength to persist and to augment itself in the plant creation. Its marked development amongst plants began with the acquirement of terrestrial life, and with the consequent evolution of the asexual or sporophytic type of vegetation. Normally, the higher type of plant bears its parts more or less equally upon all sides, and the limit to growth is still determined by the immediate environment of the given individual or of its recent ancestors. Its evolution has been acephalic, diffuse, or headless, and the individual plant or tree has no proper concentration of parts. For the most part, it is filled with unspecialized plasma, which, when removed from the parent individual (as in cuttings and grafts), is able to reproduce another like individual. The arrangements of leaves, branches, the parts of the flower, and even of seeds in the fruit, are thus rotate or circular, and in the highest type of plants the annual lateral increments of growth are disposed in like fashion ; and it is significant to observe that in the compositæ, which is considered to be the latest and highest general type of plant-form, the rotate or centrifugal arrangement is most emphatically developed. The circular arrangement of parts is the typical one for higher plants, and any departure from this form is a specialization and demands explanation.

The point I wish to urge, therefore, is the nature of the obvious or external divergence of plant-like and animal-like lines of ascent. The significance of the bilateral structure of animal-types is well understood, but this significance has been drawn, so far as I know, from a comparison of bilateral or dimeric animals with rotate or polymeric animals. I want to put a larger meaning into it, by making bilateralism the symbol of the onward march of animal evolution and circumlateralism (if I may invent the term) the symbol of plant evolution. The suggestion, however, applies simply to the general arrangement of the parts or organs of the plant body, and has no relation whatever to functional attributes or processes. It is a suggestion of analogues, not of homologues. We may, therefore, contrast these two great lines of ascent, which, with so many vicissitudes, have come up through the ages, as Dipleurogenesis and Centrogenesis.

The two divergent directions of the lines or phyla of evolution have often been the subject of comment, but one of the sharpest contrasts between the two was made in 1884 by Cope, when he proposed that the vegetable kingdom has undergone a degenerate or retrogressive evolution. "The plants in general," he then wrote, "in the persons of their protist ancestors, soon left a free-swimming life and became sessile. Their lives thus became parasitic, more automatic, and, in one sense, degenerate." The evolution of the plant creation is, therefore, held to be a phenomenon of catagenesis or decadence. This, of course, is merely a method of stating a comparison with the evolution of the animal line or phylum, and is therefore of the greatest service. For myself, however, I dislike the terms retrogressive, catagenetic, and the like, as applied to the plant creation, because they imply intrinsic or actual degeneracy. True retrogressive or degenerate evolution is the result of loss of attributes. Cope holds that the chief proof of degeneracy in the plant world is the loss of a free-swimming habit, but it is possible that the first life-plasma was stationary ; at any rate, we do not know that it was motile. Degeneracy is unequivocally seen in certain restricted groups where the loss of characters can be traced directly to adaptive changes, as in the loss of limbs in the serpents. Retarded evolution expresses the development of the plant world better than the above terms, but even this is erroneous because plant types exhibit quite as complete an adaptation to an enormous variety of conditions as animals do, and theré has been rapid progress towards specialization of structure. As a matter of fact, the vegetable world does not exhibit, as a whole, any backward step, any loss of characters once gained, nor any stationary or retarded periods; but its progress has been widely unlike that of the animal world and it has not reached the heights which that line of ascent has attained. The plant phylum cannot be said to be catagenetic, but suigenetic. Or, in other words, it is centrogenetic as distinguished from dipleurogenetic.

The hearer should be reminded, at this point, of the curious alternation of generations which has come about in the plant world. One generation develops sexual functions, and the product of the sexual union is an asexual generation, and this, in turn, gives rise to another sexual generation like the first. In the lowest sex-plants, as the algæ, the sexual generation—or the gametophyte, as it is called—generally comprises the entire plant body, and the asexual generation—or sporophyte—develops as a part of the fructifying structure of the gametophyte, and is recognizable as a separate structure only by students of special training. In the fungi, which are probably of catagenetic evolution, alternation of generations is very imperfect or wanting. In the true mosses, the gametophyte is still the conspicuous part of the plant structure. It comprises all that part of the moss which the casual observer recognizes as "the plant." The sporophytic generation is still attached to the persistent gametophyte, and it is the capsule with its stem and appendages. In the ferns, however, the gametophytic stage is of short duration. It is the inconspicuous prothallus, which follows the germination of the spore. Therefrom originates "the fern," all of which is sporophytic, and the gametophyte perishes. With the evolution of the flowering plants, the gametophyte becomes still more rudimentary, whilst the sporophyte is the plant, tree or bush, as we see it. The gametophytic generation is associated with the act of fertilization, the male prothallus or gametophyte developing from the pollen grain and soon perishing, and the female prothallus or gametophyte developing in the ovule and either soon perishing or persisting in the form of the albumen of the seed. The great development of the sporophyte in later time is no doubt a consequence of the necessity of assuming a terrestrial life; and with this development has come the perfection of the centrogenic form.

2. *The Origin of Differences.*

The causes which have contributed to the origin of the differences which we see in the organic creation have been and still are the subjects of the most violent controversy. Those persons who conceive these differences to have come into existence full-formed, as they exist at the present time, are those who believe in the dogma of special creations, and they usually add to the doctrine a belief in design in nature. This doctrine of special creation receives its strongest support when persons contrast individual objects in nature. Certainly nothing can seem more unlike in very fundamental character than an insect and an elephant, a star-fish and a potato, a man and an oak tree. The moment one comes to study the genealogies of these subjects or groups, however, he comes upon the astonishing fact that the ancestors are more and more alike the farther back they are traced. In other words, there are great series of convergent histories. Every naturalist, therefore, is compelled to admit that differences in nature have somehow been augmented in the long processes of time. It is unnecessary, therefore, that he seek the causes of present differences until he shall have determined the causes of the smallest or original differences. It is thus seen that there are two great and coördinate problems in the study of evolution, the causes of initial differences, and the means by which differences are augmented. These two problems are no doubt very often expressions of the same force or power, for the augmentation of a difference comes about by the origination of new degrees of difference, that is, by new differences. It is very probable that the original genesis of the differences is often due to the operation of the very same physiological processes which gradually enlarge the difference into a gulf of wide separation.

In approaching this question of the origin of unlikenesses, the inquirer must first divest himself of the effects of all previous teaching and thinking. We have reason to assume that all beings came from one original life-plasma, and we must assume that this plasma had the power of perpetuating its physiological identity. Most persons still further assume that this plasma must have been endowed with the property of reproducing all its characters of form and habit exactly, but such assumption is wholly gratuitous and is born of the age-long habit of thinking that like produces like. We really have no right to assume either that this plasma was or was not constituted with the power of exact reproduction of all its attributes, unless the behavior of its ascendants forces us to the one or the other conclusion. Inasmuch as no two individual organisms ever are or ever have been exactly alike, so far as we can determine, it seems to me to be the logical necessity to assume that like never did and never can produce like. The closer we are able to approach to plasmodial and unspecialized forms of life in our studies of organisms, the more are we impressed with the weakness of the hereditary power. Every tyro in the study of protoplasm knows that the amœba has no form. The shapes which it assumes are individual, and do not pass to the descendants. To my mind, therefore, it is a more violent assumption to suppose that this first unspecialized plasma should exactly reproduce all its minor features than to suppose that it had no distinct hereditary power and therefore, by the very nature of its constitution, could not exactly reproduce itself. The burden of proof has been thrown upon those who attempt to explain the initial origin of differences, but it should really be thrown upon those who assume that life-matter was originally so constructed as to rigidly recast itself into one mould in each succeeding generation. I see less reason for dogmatically assuming that like produces like than I do for supposing that unlike produces unlike.

I advanced this proposition a year ago in my *Plant-Breeding* (pp, 9, 10), and I am now glad to find, since writing the above paragraph, that H. S. Williams has reached similar conclusions in his new *Geological Biology*. He regards mutability as the fundamental law of organisms, and speaks of the prevalent notion that organisms must necessarily reproduce themselves exactly as "one of the chief inconsistencies in the prevalent conception of the nature of organisms." "While the doctrine of mutability of species has generally taken the place of immutability," he writes, "the proposition that like produces like in organic generation is still generally, and I suppose almost universally, accepted. It therefore becomes necessary to suppose that variation is exceptional, and that some reason for the accumulation of variation is necessary to account for the great divergencies seen in different species. . . . . The search has been for some cause of the variation : it is more probable that mutability is the normal law of organic action, and that permanency is the acquired law." I do not suppose that Professor Williams makes definite variation an inherent or necessary quality of organic matter, but that this matter had no original hereditary power and that its form and other attributes in succeeding generations have been moulded into the environment, and that the burden of proof is thrown upon those who assume that life-matter was endowed with the property that like necessarily produces like. At all events, this last is my own conception of the modification of the streams of ascent.

In other words, I look upon heredity as an acquired character, the same as form or color or sensation is, and not as an original endowment of matter. The hereditary power did not originate until for some reason it was necessary for a given character to reproduce itself, and the longer any form or character was perpetuated, the stronger became the hereditary power.

It is now pertinent to inquire what determined the particular differences which we know to have persisted. The mere statement that some forms became sessile or attached to the earth, and that others became or remained motile, is an assumption that these differences were direct adaptations to environment. Every little change in environment incited a corresponding change in the plastic organization ; and the greater and more various the changes in the physical attributes of the earth with the lapse of time, the greater became the modifications in organisms. I believe, therefore, that the greater part of present differences in organisms are the result directly and indirectly of external stimuli, until we come into those higher ranges of being in which sensation and volition have developed, and in which the effects of use and disuse and of psychological states have become increasingly more important as factors of ascent. The whole moot question, then, as to whether variations are definite or multifarious, is aside from the issue. They are as definite as the changes in the environment, which determine and control their existence. More differences arise than can persist, but this does not prove that those which are lost are any the less due to the impinging stimuli. Those who write of definite variation, usually construe the result or outcome of some particular evolution into a measure of the variation which is conceived to have taken place in the group. Most or all of the present characters of any group are definite because they are the survivals in a process of elimination ; but there may have been, at various times, the most diverse and diffuse variations in the very group which is now marked by definite attributes. As the lines of ascent developed, and generation followed generation in countless number, the organization was more and more impressed with the features of ancestral characters, and these ancestral characters are the more persistent as they have been more constant in the past. But these characters, which appear as hereditary or atavistic variations in succeeding generations, were no doubt first, at least in the plant creation, the offspring, for the most part, of the environment reacting upon the organism. As life has ascended in the time-scale and has become increasingly complex, so the operation of any incident force must ever produce more diverse and unpredictable results. What I mean to say is that, in plants, some of the variations seem to me to be the resultants of a long line of previous incident impressions, or have no immediate inciting cause. Such variation is, to all appearances, fortuitous. It is, therefore, evident that the study of the effects of impinging environments at the present day may not directly elucidate the changes which similar conditions may have produced in the beginning.

Whilst the steadily ascending line of the plant creation was fitting itself into the changing moods of the external world, it was at the same time developing an internal power. Plants were constantly growing larger and stronger or more specialized. The accumulation of vital energy is an acquired character the same as peculiarities of form or structure are. It is the accumulated result of every circumstance which has contributed to the well-being and virility of the organism. The gardener knows that he can cause the plant to store up energy in the seed, so that the resulting crop will be the larger. Growth is itself but the expression or result of this energy which has been picked up by the way through countless ages. Now, mere growth is variation. It results in differences. Plants cannot grow without being unlike. The more luxuriant the growth, the more marked the variation. Most plants have acquired or inherited more growth-force than they are able to use because they are held down to certain limitations by the conditions in which they are necessarily placed by the struggle for existence. I am convinced that many of the members of plants are simply outgrowths resulting from this growth-pressure, or as Bower significantly speaks of them ("A Theory of the Strobilus in Archegoniate Plants," *Annals of Botany*, viii, 358, 359), the result of an "eruptive process." The pushing out of shoots from any part of the plant body, upon occasion, the normal production of adventitious plantlets upon the stems and leaves of some begonias (especially *Begonia phyllomaniaca*), bryophyllum, some ferns, and many other plants, are all expressions of the growth-force which is a more or less constant internal power. This growth-force may give rise to more definite variations than impinging stimuli do; but the growth-force runs in definite directions because it, in its turn, is the survival in a general process of elimination. Many of the characters of plants which—for lack of better explanation—we are in the habit of calling adaptive, are no doubt simply the result of eruption of tissue. Very likely some of the compounding of leaves, the pushing out of some kinds of prickles, the duplication of floral organs, and the like, are examples of this kind of variation. We know that the characters of the external bark or cortex upon old tree trunks are the result of the internal pressure in stretching and splitting it. This simply shows how the growth-force may originate characters of taxonomic significance when it is expressed as mere mechanical power acting upon tissue of given anatomical structure. This power of growth is competent, I think, to originate many and important variations in plants. I suppose my conception of it to be essentially the same as that of the bathmism of Cope, and the "Theory of the Organic Growth" of Eimer.

We have now considered two general types of forces or agencies which start off variations in plants—purely external stimuli, and the internal acquired energy of growth. There is still a third general factor, crossing, or, as Eimer writes it, "sexual mixing." The very reason for the existence of sex, as we now understand it, is to originate differences by means of the union of two parents into one offspring. This sexual mixing cannot be considered to be an original cause of unlikenesses, however, since sex itself was at first a variation induced by environment or other agencies, and its present perfection, in higher organisms, is the result of the process of continuous survival in a conflict of differences.

The recent rise of Lamarckian views seems to have been largely the result of an attempt to discover the *vera causa* of variations. Darwin's hypothesis of natural selection assumes variability without inquiring into its cause, and writers have therefore said that Darwin did not attempt to account for the cause of variations. Nothing can be farther from his views. Yet some of our most recent American writings upon organic evolution repeat these statements. Cope, in his always admirable *Primary Factors of Organic Evolution*, writes that "Darwin only discussed variation after it came into being." Yet Darwin's very first chapter in his *Origin of Species* contains a discussion of the "Causes of Variability," and the same subject is gone over in detail in *Variation of Animals and Plants Under*

Domestication. Darwin repeatedly refers the cause or origin of variation to "changed conditions of life," which is essentially the position maintained by the Lamarckians, and he as strenuously combats those who hold that definite variation is an innate attribute of life. "But we must, I think, conclude . . . ." writes Darwin in the latter book, "that organic beings, when subjected during several generations to any change whatever in their conditions, tend to vary." He discussed, at length, the particular agencies which he considered to be most potent in inducing variability, and enumerated, amongst other factors, the kind and amount of food, climate and crossing. "Changes of any kind in the conditions of life," he repeats, "even extremely slight changes, often suffice to cause variability. Excess of nutriment is perhaps the most efficient single exciting cause." Cope, in his discussion of the "Causes of Variation," starts out with the proposition "to cite examples of the direct modifying effect of external influences on the characters of individual animals and plants;" and he closes with this paragraph: "I trust that I have adduced evidence to show that the stimuli of chemical and physical forces, and also molar motion or use and its absence, are abundantly sufficient to produce variations of all kinds in organic beings. The variations may be in color, proportions, or details of structure, according to the conditions which are present." This is, in great part, the thesis to which Darwin extended the proofs of a most laborious collection of data from gardeners and stock-breeders and from feral nature. It has been the great misfortune of the interpretation of Darwin's writings that his hypothesis of natural selection has so completely overtopped everything else in the reader's mind that other important matters have been overlooked.

Whilst the one central truth in the plant creation is the fact that differences arise as a result of variations in environment, there are nevertheless many exceptions to it. There are various types of differences which are merely incidental or secondary to the main stem of adaptive ascent. Some of these are such as arise from the cessation of the constructive agencies, and others are mere correlatives or accompaniment of type differences. As an example of the former, we may cite the behavior of the potato. By high cultivation and careful breeding, the plant has been developed to produce enormous crops of very large tubers, so heavy a crop that the plant has been obliged to spare some of its energy from the production of pollen and berries for the purpose of maintaining the subterranean product. It is evident that this high state of amelioration can be maintained only by means of high cultivation. The moment there is a let-down in the factors which have bred and maintained the plant, there is a tendency towards a breaking up and disappearance of the high bred type. This is an illustration of the phenomenon of panmixia, as outlined by Weismann, except that the force which has ceased to act is human selection rather than natural selection. "This suspension of the preserving influence of natural selection," Weismann writes, "may be termed Panmixia." In his opinion, "the greater number of those variations which are usually attributed to the direct influence of external conditions of life, are to be attributed to panmixia. For example, the great variability of most domesticated animals and plants essentially depends upon this principle." In other words, certain differences are preserved through the agency of natural selection, and certain differences are lost; if the organism is removed from this restraining and directing agency, all variations have the chance of asserting themselves. "All individuals can reproduce themselves," Weismann explains, "and thus stamp their characters upon the species, and not only those which are in all respects, or in respect to some single organ, the fittest." I am convinced that this term expresses a very important truth, and one which, as Weismann says, is particularly apparent in domestic animals and plants; but panmixia does not express an incident force. If new differences arise in consequence of the cessation of the directive agency of natural selection, it is because they were first impressed upon the organization by some unaccountable agency; or, if there is simply a falling away from accumulated characters, the residuary or secondary features which appear are probably the compound and often deteriorated result of various previous incident forces. In short, panmixia is a name for a class of phenomena, and it cannot be considered as itself an original cause of variation. It is, to my mind, largely the unrestrained expression or unfolding of the growth-force consequent upon the removal of the customary pressure under which the plant has lived.

3. *The Survival of the Unlike.*

The one note of the modern evolution speculations which has resounded to the remotest corner of civilization, and which is the chief exponent of current speculation respecting the origin and destiny of the organic world, is Spencer's phrase, "the survival of the fittest." This epigram is an epitome of Darwin's law of natural selection, or "the preservation, during the battle for life, of varieties which possess any advantage in structure, constitution or instinct." In most writings, these two phrases —"natural selection" and "the survival of the fittest"—are used synonymously; but in their etymology they really stand to each other in the relation of process and result. The operation of natural selection results in the survival of the fittest. One must not be too exact, however, in the literal application of such summary expressions as these. Their particular mission is to afford a convenient and abbreviated formula for the designation of important principles, for use in common writing and speech, and not to express a literal truth. Darwin was himself well aware of the danger of the literal interpretation of the epigram "natural selection." "The term 'natural selection,'" he writes, "is in some respects a bad one, as it seems to imply conscious choice; but this will be disregarded after a little familiarity." This technical use of the term "natural selection" is now generally accepted unconsciously; and yet there have been recent revolts against it upon the score that it does not itself express a literal principle or truth. If we accept the term in the sense in which it was propounded by its author, we are equally bound to accept "survival of the fittest" as a synonymous expression because its author so designed it. "By natural selection or survival of the fittest," writes Spencer, "by the preservation in successive generations of those whose moving equilibria happen to be least at variance with the requirements, there is eventually produced a changed equilibrium completely in harmony with the requirements."

It should be said that there is no reason other than usage why the phrase "survival of the fittest" should not apply to the result of Lamarckian or functional evolution as well as of Darwinian or selective evolution. It simply expresses a fact without designating the cause or the process. Cope has written a book upon the "Origin of the Fittest," in which the argument is Lamarckian. The phrase implies a conflict, and the loss of certain contestants and the salvation of certain others. It asserts that the contestants or characters which survive are the fittest, but it does not explain whether they are fit because endowed with greater strength, greater prolificness, completer harmony with surroundings, or other attributes. I should like to suggest, therefore, that the chiefest merit of the survivors is unlikeness, and to call your attention for a few minutes to the significance of the phrase—which I have used in my teaching during the last year—the survival of the unlike.

This phrase—the survival of the unlike—expresses no new truth, but I hope that it may present the old truth of vicarious or non-designed evolution in a new light. It defines the fittest to be the unlike. You will recall that in this paper I have dwelt upon the origin and progress of differences rather than of definite or positive characters. I am so fully convinced that, in the plant creation, a new character is useful to the species because it is unlike its kin, that the study of difference between individuals has come to be, for me, the one absorbing and controlling thought in the contemplation of the progress of life. These differences arise as a result of every impinging force—soil, weather, climate, food, training, conflict with fellows, the strain and stress of wind and wave and insect visitors—as a complex resultant of many antecedent external forces, the effects of crossing, and also as the result of the accumulated force of mere growth ; they are indefinite, non-designed, an expression of all the various influences to which the passive vegetable organism is or has been exposed ; those differences which are most unlike their fellows or their parents find the places of least conflict, and persist because they thrive best and thereby impress themselves best upon their offspring. Thereby there is a constant tendency for new and divergent lines to strike off, and these lines, as they become accented, develop into what we, for convenience sake, have called species. There are, therefore, as many species as there are unlike conditions in physical and environmental nature, and in proportion as the conditions are unlike and local are the species well defined. But to nature, perfect adaptation is the end ; she knows nothing, *per se*, as species or as fixed types. Species were created by John Ray, not by the Lord ; they were named by Linnæus, not by Adam.

I must now hasten to anticipate an objection to my phrase which may arise in your minds. I have said that when characters are unlike existing characters they stand a chance of persisting ; but I do not desire to say that they are useful in proportion as they are unlike their kin. I want to express my conviction that mere sports are rarely useful. These are no doubt the result of very unusual or complex stimuli, or of unwonted refrangibility of the energy of growth, and not having been induced by conditions which act uniformly over a course of time, they are likely to be transient. I fully accept Cope's remark that there is " no ground for believing that sports have any considerable influence on the course of evolution. . . . . The method of evolution has apparently been one of successional increment and decrement of parts along definite lines." Amongst domestic animals and plants the selection and breeding of sports, or very unusual and marked variations, has been a leading cause of their strange and diverse evolution. In fact, it is in this particular thing that the work of the breeder and the gardener are most unlike the work of nature. But in feral conditions, the sport may be likened to an attribute out of place ; and I imagine that its chief effect upon the phylogeny of a race—if any effect it have—is in giving rise in its turn to a brood of less erratic unlikenesses. This question of sports has its psychological significance, for if the way becomes dark the wanderer invokes the aid of this *ignus fatuus* to cut short his difficulties. Sir William Thompson supposes that life may first have come to earth by way of some meteor, and Brinton proposes that man is a sport from some of the lower creation. It is certainly a strange type of mind which ascribes a self-centred and self-sufficient power to the tree of life, and then, at the very critical points, adopts a wholly extraneous force and one which is plainly but a survival of the old cataclysmic type of mind ; and it is the stranger, too, because such type of explanation is not suggested by observation or experiment, but simply by what is for the time an insuperable barrier of ignorance of natural processes. If evolution is true at all, there is reason to suppose that it extends from beginning to finish of creation, and the stopping of the process at obscure intervals is only a temporary satisfaction to a mind that is not yet fully committed to the eternal truth of ascent. The tree of life has no doubt grown steadily and gradually, and the same forces, variously modified by the changing physical conditions of the earth, have run on with slow but mighty energy until the present time. Any radical change in the plan would have defeated it, and any mere accidental circumstance is too trivial to be considered as a modifying infiuence of the great onward movement of creation, particularly when it assumes to account for the appearing of the very capstone of the whole mighty structure.

Bear with me if I recite a few specific examples of the survival of the unlike, or of the importance, to organic types, of gradually widening differences. Illustrations might be drawn from every field of the organic creation, but I choose a few from plants because these are the most neglected and I am most familiar with them. These are given to illustrate how important external stimuli are in originating variation, and how it is that some of these variations persist.

Let me begin by saying that a good gardener loves his plants. Now, a good gardener is one who grows good plants, and good plants are very unlike poor plants. They are unlike because the gardener's love for them has made them so. The plants were all alike in November; in January, the good gardener's plants are strong and clean, with large dense leaves, a thick stem, and an abundance of perfect flowers; the poor gardener's plants are small and mean, with curled leaves, a thin hard stem, and a few imperfect flowers. You will not believe now that the two lots were all from the same seed-pod three months ago. The good gardener likes to save his own seeds or make his own cuttings; and next year his plants will be still more unlike his neighbor's. The neighbor tries this seed and that, reads this bulletin and that, but all avails nothing simply because he does not grow good plants. He does not care for them tenderly, as a fond mother cares for a child. The good gardener knows that the temperature of the water and the air, the currents in the atmosphere, the texture of the soil, and all the little amenities and comforts which plants so much enjoy, are just the factors which make his plants successful; and a good crop of anything, whether wheat or beans or apples, is simply a variation.

And do these unlikenesses survive? Yes, verily! The greater part of the amelioration of cultivated plants has come about in just this way,—by gradual modifications in the conditions in which they are grown, by means of which unlikenesses arise; and then by the selection of seeds from the most coveted plants. Even at the present day, there is comparatively little plant-breeding. The cultivated flora has come up with man, and if it has departed immensely from its wild prototypes, so has man. The greater part of all this has been unconscious and unintended on man's part, but it is none the less real.

As an illustration of how large the factors of undesigned choice and selection are in the amelioration of the domestic flora, let me ask your attention to the battle of the seed-bags. In the year 1890, the census records show, for the first time, the number of acres in the United States devoted to the growing of seed. I give the acreage of three representative crops, and these figures I have multiplied by the average seed-yields per acre in order to arrive at an approximate estimate of the entire crop produced, and the number of acres which the crop would plant. I have used low averages of yields in order to be on the safe side, and I have likewise used liberal averages of the quantity of seed required to plant an acre when making up the last column:

	Acres.	Average yield per acre.	Approximate crop.	Would plant.
Cabbage,	1,268	200 lbs.	253,600 lbs.	1,014,400 acres.
Cucumber,	10,219	120 "	1,226,280 "	613,140 "
Tomato,	4,356	80 "	368,480 "	1,473,920 "

The last column in this table has particular interest because it shows the enormous acreage which these seeds, if all planted, would cover. We are now curious to know if such areas really are planted to these species, and if they are not, it will be pertinent to inquire what becomes of the seeds. Unfortunately, we have no statistics of the entire acreages of these various truck-garden crops, but the same census gives the statistics of the commercial market gardens of the country. Inquiry of seed-merchants has convinced me that about one-fourth of all the seeds sold in any year go to market gardeners. I have therefore multiplied the census figures of market gardens by four for the purpose of arriving at an estimate of the total acreage of the given crops in the United States ; and I have introduced the last column from the above table for purposes of comparison :

	Acreage of market gardens.	Probable total acreage.	There are seeds enough to plant	Difference.
Cabbage,	77,094	308,376	1,014,400 acres.	706,024 acres.
Cucumber,	4,721	18,884	613,140 "	594,256 "
Tomato,	22,802	91,208	1,473,920 "	1,382,712 "

It will thus be seen that there are enough cabbage seeds raised in this country each year—if the census year is a fair sample—to plant nearly three-quarters of a million acres more than actually are planted ; about the same surplus of cucumber seeds ; and a surplus of tomato seeds sufficient to plant over one and a quarter million acres. It is possible, of course, that the figures of actual acreage of these crops are too low ; but such error, if it occur, must be much overbalanced by the large quantities of home-grown and imported seeds which are used every year. These startling figures would not apply so well to many other crops which are detailed in the census bulletin. For instance, the peas raised in this country would plant only about 46,000 acres, whilst there are over 100,000 acres actually grown ; but this discrepancy is probably accounted for by the fact that the larger part of the seed peas are grown in Canada and therefore do not figure in our census. There is a somewhat similar discrepancy in the watermelon, but in this crop the seeds are very largely home-saved by the heavy planters in the South and West. I do not give these figures for their value as statistics, but simply for the purpose of graphically expressing the fact that many more seeds are raised by cultivators each average year than are ever grown into plants, and that the struggle for existence does not necessarily cease when plants are taken under the care of man.

What, now, becomes of this enormous surplus of seeds? Let us take a rough survey of the entire seed crop of any year. In the first place, a certain percentage of the seeds is laid aside by the seedsman as a surety against failure in the year to come. Much of this old stock never finds its way into the market and is finally discarded. We will estimate this element of waste as twenty per cent. Of the eighty per cent. which is actually sold, perhaps another ten per cent. is never planted, leaving about seventy per cent. which finds its way into the ground. These two items of loss are pure waste and have no effect upon the resulting crop. Now, of the seeds which are planted, not more than seventy-five per cent. can be expected to germinate. That is, there is certainly an average loss of twenty-five per cent. in nearly all seeds—and much more in some—due to inherent weakness, and seventy-five per cent. represents the survival in a conflict of strength. We have now accounted for about half of the total seed product of any year. The remaining half produces plants ; but here the most important part of the conflict begins. In the crops mentioned above, much less than half of the seeds which are grown ever appear in the form of a crop. We must remember, moreover, that in making the estimate of the number of acres which these seeds would plant, I have used the customary estimates of the quantity of seeds required to plant an acre. Now, these estimates of seedsmen and planters are always very liberal. Every farmer sows from five to twenty times more seeds than he needs. Some years ago, I sowed seeds according to the recommendation of one of our best seedsmen, and I found that peas would be obliged to stand four-fifths of an inch apart, beets about twenty to the foot, and other vegetables in like confusion. I suppose that of all the seeds which actually come up, not more than one in ten or a dozen, in garden vegetables, ever give mature plants. What becomes of the remainder? They are thinned out for the good of those which are left.

This simple process of thinning out vegetables has had a most powerful effect upon the evolution of our domestic flora. It is a process of undesigned selection. This selection proceeds upon the differences in the seedlings. The weak individuals are disposed of, and those which are strongest and most unlike the general run are preserved. It is a clear case of the survival of the unlike. The laborer who weeds and thins your lettuce bed unconsciously blocks out his ideas in the plants which he leaves. But all this is a struggle of Jew against Jew, not of Jew against Philistine. It is a conflict within the species, not of species against species. It therefore tends to destroy the solidarity of the specific type, and helps to introduce much of that promiscuous unlikeness which is the distinguishing characteristic of domestic plants.

Let us now transfer this emphatic example to wild nature. There we shall find the same prodigal production of seeds. In the place of the gardener undesignedly moulding the lines of divergence, we find the inexorable physical circumstances into which the plastic organisms must grow, if they grow at all. These circumstances are very often the direct causes of the unlikenesses of plants, for plants which start like when they germinate may be very unlike when they die. Given time and constantly but slowly changing conditions, and the vegetable creation is fashioned into the unlikenesses which we now behold. With this conception, let us read again Francis Parkman's picturesque description of the forest of Maine in his *Half-Century of Conflict:* "For untold ages Maine had been one unbroken forest, and it was so still. Only along the rocky seaboard, or on the lower waters of one or two great rivers a few rough settlements had gnawed slight indentations into this wilderness of woods, and a little farther inland some dismal clearing around a block-house or stockade let in the sunlight to a soil that had lain in shadow time out of mind. This waste of savage vegetation survives, in some part, to this day, with the same prodigality of vital force, the same struggle for existence and mutual havoc that mark all organized beings, from men to mushrooms. Young seedlings in millions spring every summer from the black mould, rich with the decay of those that had preceded them, crowding, choking and killing each other, perishing by their very abundance; all but a scattered few, stronger than the rest, or more fortunate in position, which survive by blighting those about them. They in turn, as they grow, interlock their boughs, and repeat in a season or two the same process of mutual suffocation. The forest is full of lean saplings dead or dying with vainly stretching towards the light. Not one infant tree in a thousand lives to maturity; yet these survivors form an innumerable host, pressed together in struggling confusion, squeezed out of symmetry and robbed of normal development, as men are said to be in the level sameness of democratic society. Seen from above, their mingled tops spread in a sea of verdure basking in light; seen from below, all is shadow, through which spots of timid sunshine steal down among legions of dark, mossy trunks, toadstools and rank ferns, protruding roots, matted bushes, and rotting carcases of fallen trees. A generation ago one might find here and there the rugged trunk of some great pine lifting its verdant spire above the indistinguished myriads of the forest. The woods of Maine had their aristocracy; but the axe of the woodman has laid them low, and these lords of the wilderness are seen no more."

In such bold and generalized examples as this, the student is able to discern only the general fact of progressive divergency and general adaptation to conditions, without being able to discover the particular directive forces which have been at the bottom of the evolution. It is only when one considers a specific example that he can arrive at any just conclusions respecting initial causes of modification. Of adaptive modifications, two general classes have been responsible for the ascent of the vegetable kingdom, one a mere moulding or shaping into the passive physical environments, the other the direct result of stress or strain imposed upon the organism by wind and water and by the necessities of a radical change of habit from aquatic to terrestrial life, and later on by the stimuli of insects upon the flowers. One of the very best examples of the mere passive ascent is afforded by the evolution of the root as a feeding organ; and a like example of development as a result of strain is afforded by the evolution of the stem and vascular or fibrous system. Our present flora, like our present fauna, is an evolution from aquatic life. The first sessile or stationary plants were undoubtedly stemless. As the waters increased in depth and plants were driven farther and farther from their starting points by the struggle for place and the disseminating influence of winds and waves, the plant body became more and more elongated. Whilst the plant undoubtedly still absorbed food throughout its entire periphery, it nevertheless began to differentiate into organs. The area chiefly concerned in food-gathering became broadened into a thallus, a constricted or stem-like portion tended to develop below, and the entire structure anchored itself to the rock by a hold-fast or grapple. This hold-fast or so-called root of most of our present sea-weeds is chiefly a means of holding the plant in place, and it probably absorbs very little food. As plants emerged into amphibian life, however, the foliar portion was less and less thrown into contact with food, and there was more and more demand upon the grapple which was anchored in the soil. The foliage gradually developed into organs for absorbing gases and the root was forced to absorb the liquids which the plant needed. I do not mean to say that there is any genetic connection between the sea-weeds and the higher plants, or that the roots of the two are homologous; but to simply state the fact that, in point of time, the hold-fast root developed before the feeding root did, and that this change was plainly one of adaptation. Specialized forms of flowering plants, which inhabit water, still show a root system which is little more than an anchor, and the foliage actively absorbs water. The same environmental circumstances are thus seen to have developed organs of similar physiological character in widely remote times and in diverse lines of the plant evolution. "As the soil slowly became thicker and thicker," writes King in his book upon *The Soil*, "as its water-holding power increased, as the soluble plant food became more abundant, and as the winds and the rains covered at times with soil portions of the purely superficial and aërial early plants, the days of sunshine between passing showers, and the weeks of drought intervening between periods of rain, became the occasions for utilizing the moisture which the soil had held back from the sea. These conditions, coupled with the universal tendency of life to make the most of its surroundings, appear to have induced the evolution of absorbing elongations, which, by slow degrees and centuries of repetition, came to be the true roots of plants as we now know them." Some aquatic flowering plants are, as we have seen, still practically rootless and they absorb the greater part of their food directly by the foliar parts; but the larger number of the higher plants absorb their mineral food by means of what has come to be a subterranean feeding organ, and the foliar parts have developed into gas-absorbing organs and they take in water only when forced to do so under stress of circumstances.

But as a mere feeding organ, the root requires no fibrous structure. It is still a hold-fast or grapple and its mechanical tissue has developed enormously, along with that of the stem, in order to preserve the plant against the strain of the moving elements and to maintain its erectness in aërial life. When this self-poised epoch arrives, the vegetable world begins its definite and steady ascent in centrogenic form. Whilst the animal creation leaves its centrogenic arrangement early in its own time-scale, the plant creation assumes such arrangement at a comparatively late epoch in its time-scale.

Perhaps the best illustration which I can bring you of the origin of the unlike by means of environmental conditions and the survival of some of this unlikeness in the battle for life, is the development of the winter quiescence of plants. What means all this bursting verdure of the liquid April days? Why this annually returning miracle of the sudden expansion of the leaf and flower from the lifeless twigs? Were plants always so? Were they designed to pass so much of their existence in the quiescent and passive condition? No. The first plants had no well-defined cycles, and they were born to live, not to die. There were probably no alternations of seasons in the primordial world. Day alternated with night, but month succeeded month in almost unbroken sameness age after age. As late as the Carboniferous time, according to Dana, the globe "was nowhere colder than the modern temperate zone, or below a mean temperature of 60° F." The earth had become wonderfully diverse by the close of the Cretaceous time, and the cycads and their kin retreated from the poles. Plants grew the year round; and as physical conditions became diverse and the conflict of existence increased, the older and the weaker died. So a limit to duration, that is, death, became impressed upon the individuals of the creation; for death, as seen by the evolutionist, is not an original property of life-matter, but is an acquired character, a result of the survival of the fittest. The earth was perhaps ages old, even after life began, before it ever saw a natural death; but without death all things must finally have come to a standstill. When it became possible to sweep away the old types, opportunity was left for new ones; and so the ascent must continue so long as physical conditions, which are not absolutely prohibitive of life, shall become unlike.

Species have acquired different degrees of longevity, the same as they have acquired different sizes and shapes and habits—by adaptation to their conditions of life. Annual plants comprise about half of the vegetable kingdom, and these are probably all specializations of comparatively late time. Probably the greater part of them were originally adaptations to shortening periods of growth, that is, to seasonal changes. The gardener, by forceful cultivation and by transferring plants towards the poles, is able to make annuals of perennials. Now, a true annual is a plant which normally ripens its seeds and dies before the coming of frost. Many of our garden plants are annuals only because they are killed by frost. They naturally have a longer season than our climate will admit, and some of them are true perennials in their native homes. These plants are, with us, plur-annuals, and amongst them are the tomato, red pepper, egg plant, potato, castor bean, cotton, Lima bean and many others. But there are some varieties of potatoes and other plants which have now developed into true annuals, normally completing their entire growth before the approach of frost. It is all the result of adaptation to climate, and essentially the same phenomenon is the development of the annual and biennal flora of the earth from the perennial. An interesting example of the effect of climate upon the seasonal duration of plants is the indeterminate or prolonged growth of plants in England as compared with the same plants in America. The cooler summer and very gradual approach of winter in England develop a late and indefinite maturity of the season's growth. When English plants are grown in America, they usually grow until killed by fall frosts; but after a few generations of plants, they acquire the quick and decisive habit of ripening which is so characteristic of our vegetation. I once made an extended test of onions from English and American seeds (Bull. 31, Mich. Agric. College), and was astonished to find that nearly all of the English varieties continued to grow until frost and failed "to bottom," whilst our domestic varieties ripened up in advance of freezing weather. This was true even of the Yellow Danvers and Red Wethersfield, varieties of American origin and which could not have been grown very many years in England. Every horticulturist of much experience must have noticed similar unmistakable influences of climate upon the duration of plants.

A most interesting type of examples of the quick influence of climate upon plants—not only upon their duration but upon habit and structural characters—is that associated with the growing of "stock seed" by seedsmen. Because of uncertainties of weather in the Eastern States, it is now the practice to grow seeds of onions, Lima beans and other plants in California or other warm regions; but the plants so readily acquire the habit of long-continuing growth as to be thereafter grown with difficulty in the Northeastern States. It is, therefore, necessary that the seedsman shall raise his stock seed every year in his own geographical region, and this seed is each year sent to California for the growing of the commercial seed crop. In other words, the seed of California-grown onions is sold only for the purpose of growing onion bulbs for market, and is not planted for the raising of a successive crop of seed. This results in growing only a single generation of the crop in the warm country. Onion seed from stock which has been grown in California for several years produces onions which do not "bottom" well, much as I found to be the case with the English onion seed.

But many plants, in geologic time, could not thus shorten up their life-history to adjust themselves to the oncoming of the seasons. They ceased their labors with the approach of the cold or the dry, tucked up their tender tissues in buds and resigned themselves to the elements. If a man could have stood amongst those giant mosses and fern forests of the reeking Carboniferous time, and could have known of the refrigeration which the earth was to undergo, he would have exclaimed that all living things must utterly perish. Consider the effects of a frost in May. See its widespread devastation. Yet, six months hence the very same trees which are now so blackened, will defy any degree of cold. And then, to make good the loss of time, these plants start into activity relatively much earlier in spring than the same species do in frostless climates. This very day, when frosts are not yet passed, our own New York hillsides are greener with surface vegetation than the lands of the Gulf States are, which have been frostless for two months and more. The frogs and turtles, the insects, the bears and foxes, all adjust themselves to a climate which seems to be absolutely prohibitive of life, and some animals may actually freeze during their hibernation, and yet these April days see them again in heyday of life and spirits! What a wonderful transformation is all this! This enforced period of quiescence is so impressed upon the organization that the habit becomes hereditary in plants, and the gardener says that his begonias and geraniums and callas must have a "rest," or they will not thrive. But in time he can so far break this habit in most plants as to force them into activity for the entire year. These budding days of April, therefore, are the songs of release from the bondage of winter which has come on as the earth has grown aged and cold.

I must bring still one more illustration of the survival of the unlike, out of the abundance of examples which might be cited. It is the fact that, as a rule, new types are variable and old types are inflexible. The student of fossil plants will recall the fact that the liriodendrons, ginkgos, sequoias, sassafrasses and other types came into existence with many species and are now going out of existence with one or two species. Williams has considered this feature, for extinct animal forms, at some length in his new *Geological Biology*. "Many species," he writes, "which by their abundance and good preservation in fossil state give us sufficient evidence in the case, exhibit greater plasticity in their characters at the early stage than in later stages of their history. A minute tracing of lines of succession of species shows greater plasticity at the beginning of the series than later, and this is expressed, in the systematic description and tabulation of the facts, by an increase in the number of the species." "When species are studied historically, the law appears evident that the characters of specific value . . . . present a greater degree of range of variability at an early stage in the life-period of the genus than in the later stages of that period." So marked is this incoming of new types in many cases that some students have supposed that actual special creation of species has occurred at these epochs. It should be said that there is apt to be a fallacy in observation in these instances, because the records which are, to our vision, simultaneous in the rocks may have extended over ages of time; but it is nevertheless true that some important groups seem to have come in somewhat quickly with many or several species and to have passed out with exceeding slowness.

To my mind, all this is but the normal result of the divergence of character, or the survival of the unlike. A new type finds places of least conflict, it spreads rapidly and widely, and thereby varies immensely. It is a generalized type, and therefore adapts itself at once to many and changing conditions. A virile plant is introduced into a country in which the same or similar plants are unknown, and immediately it finds its opportunity and becomes a weed, by which we mean that it spreads and thrives everywhere. Darwin and Gray long ago elucidated this fact. The trilobites, spirifers, conifers, ginkgos, were weed-types of their time, the same as the composites are to-day. They were stronger than their contemporaries, the same as our own weeds are stronger than the cultivated plants with which they grow. After a time, the new types outran their opportunity, the remorseless struggle for existence tightened in upon them, the intermediate unlikenesses had been blotted out, and finally only one or two types remained, struggling on through the ages, but doomed to perish with the continuing changes of the earth. They became specialized and inelastic; and the highly specialized is necessarily doomed to extinction. Such remnants of a vanquished host remain to us in our single liriodendron, the single ginkgo and sassafras, and the depleted ranks of the conifers.

My attention was first called to this line of thought by contemplating upon the fact that cultivated plants differ widely in variability, and I was struck by the fact that many of our most inextricably variable groups—as the cucurbits, maize, citrus and the great tribes of composites—are still unknown in a fossil state, presumably because of their recent origin. Many other variable genera, to be sure, are well represented in fossil species, as roses (although these are as late as the Eocene), pyrus, prunus and musa; but absolute age is not so significant as the comparative age of the type, for types which originated very far back may be yet in the comparative youth of their development. The summary conclusions of a discussion of this subject were presented to the American Association for the Advancement of Science two years ago.* A modification of these points, as I now understand them, would run something as follows:

1. There is a wide difference in variability in cultivated plants. Some species vary enormously, and others very little.

2. This variability is not correlated with age of cultivation, degree of cultivation, or geographical distribution.

3. Variability of cultivated plants must be largely influenced and directed, therefore, by some antecedent causes.

4. The chief antecedent factor in directing this variability is probably the age of the type. New types, in geologic time, are polymorphous; old types are monomorphous and are tending towards extinction. The most flexible types of cultivated plants are such as have probably not yet

* *Proc. A.A.A.S.* 1894, 255; *Botanical Gazette*, xix. 381.

passed their zenith, as the cucurbits, composites, begonias and the like. The varieties of cereals, which are old types, are so much alike that expert knowledge is needed to distinguish them.

5. New types are more variable and flexible because less perfectly moulded into and adjusted to the circumstances of life than the old types are. They have not yet reached the limits of their dissemination and variation. They are generalized forms.

The reader will please observe that I have here regarded the origin and survival of the unlike in the plant creation in the sense of a plastic material which is acted upon by every external stimulus and which must necessarily vary from the very force of its acquired power of growth, and the unlikenesses are preserved because they are unlike. I have no sympathy with the too prevalent idea that all the attributes of plants are direct adaptations or that they are developed as mere protections from environment and associates. There is a type of popular writings which attempts to evolve many of the forms of plants as a mere protection from assumed enemies. Perhaps the plant features which have been most abused in this manner, are the spines, prickles and the like, and the presence of acrid or poisonous qualities. As a sample of this type of writing, I will make an extract from Massee's *Plant World:*

"Amongst the most prominent and general modes of protection of vegetative parts against the attacks of living enemies may be mentioned *prickles*, as in roses and brambles, which may either be straight, and thus prevent the nibblings of animals, or, in more advanced species, curved, thus enabling the weak stem to climb and carry its leaves out of harm's way. *Spines*, that are sharp-pointed abortive branches, serving the same purpose as prickles, as in the common sloe or blackthorn (*Prunus spinosa*). *Rigid hairs* on leaves and stem, as in the borage (*Borago officinalis*), and comfrey (*Symphytum officinale*). *Stinging hairs*, as in the common nettles (*Urtica dioica*, and *U. urens*). In these cases the stinging hairs are mixed on the leaves and stem with ordinary rigid hairs, of which they are higher developments, distinguished by the lower or basal swollen portion of the hair containing an irritating liquid that is ejected when the tip of the hair is broken off. *Bitter taste*, often accompanied by a strong scent, as in wormwood (*Artemisia vulgaris*), chamomile (*Anthemis nobilis*), and the leaves and fruit of the walnut (*Juglans regia*). *Poisonous alkaloids*, as in the species of *Strychnos*, which contain two very poisonous alkaloids, strychnine and brucine, in the root and the seeds; decoctions of species of Strychnos are used by the Javanese and the natives of South America to poison their arrows. Some of the species, as *Strychnos nux-vomica*, are valuable medicines, depending on the strychnine they contain, which acts as a powerful excitant of the spinal cord and nerves; thus the most effective protective arrangements evolved by plants can be turned to account, and consequently lead to the destruction of the individuals they were designed to protect. Our common arum (*Arum maculatum*), popularly known as 'Lords and Ladies,' has an intensely acrid substance present in the leaves, which effectually protects it from the attacks of mammals and caterpillars, but not from the attacks of parasitic fungi, which appear to be indifferent to all protective contrivances exhibited by plants, nearly every plant supporting one or more of these minute pests, the effects of which will be realized by mentioning the potato disease, 'rust' and 'smut' in the various cereals, and the hop disease, all due to parasitic fungi."

Now, this is merely a gratuitous and *ad captandrum* species of argument, one which is designed to please the fancy and to satisfy those superficial spirits who are still determined to read the element of design into organic nature. It does not account for the facts. These particular attributes of plants are specialized features, and it is always unsafe to generalize upon specializations. Each and every one of such specialized features must be investigated for itself. Probably the greater number of spinous processes will be found to be the *residua* following the contraction of the plant body; others are no doubt mere correlatives of the evolution of other attributes; and some may be the eruptions of the growth-force; and the acrid and poisonous properties are quite as likely to be wholly secondary and useless features. The attempt to find a definite immediate use and office for every attribute in the creation is superficial and pernicious. There are many attributes of organisms which are not only useless, but positively dangerous to the possessor, and they can be understood only as one studies them in connection with the long and eventful history of the line of ascent.

The thought which I want to leave with you, therefore, is that unlikenesses are the greatest facts in the organic creation. These unlikenesses in plants are (1) the expressions of the ever-changing environmental conditions in which plants grow, and of the incidental stimuli to which they are exposed; (2) the result of the force of mere growth; (3) the outcome of sexual mixing. They survive because they are unlike, and thereby enter fields of least competition. The possibility of the entire tragic evolution lay in the plasticity of the original life-plasma. The plastic creation has grown into its own needs day by day and age by age, and it is now just what it has been obliged to be. It could have been nothing else.

Remarks by Prof L. H. Bailey.

Prof. Cope has given us three general proofs or series of proofs of evolution. In the first place he says there is variation; in the second place succession; and in the third place we have the proof of embryology. I might subdivide them and might add two or three more proofs which appeal to me with particular force. It seems to me that we must accept the truth of evolution on the mere fact that the earth from its beginning has undergone wonderful physical changes, affecting the organisms living upon it, and which must have adapted themselves to the changes by themselves changing. In the second place, we know that there must be an intense struggle for existence amongst all forms of life; that the result of this struggle for existence must be adaptation to the organic environment. Again, another line of proof that evolution is true is the classificatory verification. The very fragment of the tree of life which Prof. Cope has put upon the board is an evidence that there are converging histories of animals, or, in other words, that there are relationships. But the proof which appeals to me most strongly is the fact that gardeners and breeders have it in their power to make new forms and that they have been making them since man began to deal with plants and animals. The palæontological and embryological records do not appeal to me with such force as the experiences of breeders and gardeners, who for ages have been modifying plants and animals almost to suit their will. This, of course, suggests that I am not skilled in the sciences of palæontology and embryology; but have given more attention to gardening.

I assume that you all believe in evolution. Heredity is not a necessary attribute of the theories of evolution. It is a matter for the physiologists and the embryologists to discuss rather than for one who looks broadly at nature and tries to discover some of the general and fundamental facts which have determined the onward progress of creation. I wish to call your attention to the facts of the origin of differences. I speak of differences rather than of variations.

Dr. D. G. Brinton made the following remarks:

We have listened with interest to this able exposition of the principles of evolution from three eminent scholars approaching it from different points of view. The question proposed, however, was one which was intended to go beyond the mere facts of natural science. Facts are not factors. The word means something more, something deeper. When we have these series of facts laid before us, however interesting they may be, they do not themselves express the primary law of evolution, but are merely a number of incidents illustrative of it. Therefore I think that the first speaker in his clear descriptions of the palæontologic evolutionary claims gave us little information as to the factors which brought them about.

We shall no doubt grant, as was urged by the second speaker, that there are extrinsic and intrinsic factors of evolution; but what he advanced as extrinsic factors were again series of external facts, and his intrinsic factors were series of internal facts or processes. The law by virtue of which they acted upon organic forms so as to produce a varying morphology was not, it seems to me, definitely stated.

By the third speaker the doctrine of evolution has been put forward as a sort of religious dogma of the scientific church. For myself, I cannot look upon it in that light. I believe I caught his words correctly when I quote him as saying that evolution holds good "from beginning to finish of creation." I cannot see that any known facts justify such a statement. Evolution is a matter of the past not of the future. We have nothing to do with the "finish of creation," and it is not likely that we know anything about it. Such a dogma has no place in scientific bodies. All we know is, that of the many millions of organized species a few have developed into higher forms, while the immense majority have perished utterly. We have no guarantee but that evolution has reached its acme and may cease to-night. Let us hold it, therefore, as a fact of past time, not as a dogma of faith regarding the future.

Turning now to the question of the evening, What are the ultimate factors or primary causes, so far as we can trace them, which have influenced and do influence the development of organic forms? For an answer I turn to an expression once used by my teacher, Prof. James D. Dana, whose name is a household word to every man of science. His suggestive expression was, "The whole of Nature is bound in a straight-jacket of mathematics." It means that we must go back to the purely mechanical forces of the universe, if we would find the primary factors of organic variation. The last speaker well said that mutability, change, not permanence, is the law of organic life. He developed it admirably in his references to the like and the unlike, and in his statement that unlikeness is really the secret of advance. This theory, as doubtless some will remember, was that brought forward with force and beauty by the late eminent Dr. Pasteur in his remarkable papers on *Asymmetry* as the source of change in both the organic and inorganic worlds. Unquestionably he was right. Change is the law of the universe. It is no new perception of the thinking mind. Nigh two thousand years ago the philosopher Heraclitus of Ephesus laid down the principle, "All is flowing," *παντα ρει*. No two organic forms are alike, or can be alike. The son is never the image of his father; the plant never finds in its product the precise reproduction of itself. You remember how Leibnitz amused the ladies of the court by having them try to find two leaves of an oak which were alike. They tried in vain. Never anywhere is uniformity or identity; everywhere is indefinite, infinite variability.

What is the explanation of this?

I ask your attention again to the mechanical principles of nature. To them alone must we return when we search for primary agencies of change. All organic and inorganic substances are constantly subject to the innumerable forces which play upon them from all parts of the universe. Every atom of earth is influenced by each distant star. Constantly each atom is bombarded by thousands, by millions of forces, and its changes are the resultants of these.

The primary laws of motion with which we are familiar in the *Principia* of Newton are also the primary causes both of the permanence and the variability of organic forms. His first law—that motion would continue forever in the same direction unless interfered with by other motion in another direction—gives us the stability of species, the potent tendency of the individual to transmit the specific characteristics, the maintenance of traits by the germinal protoplasm, as brought out by the second speaker. It is the *conatus in se perseverare* of Spinoza.

The second law of motion is the basis of all change and variation It is, as doubtless you remember, that change of motion is proportional to force and takes place in the line of the force. Infinite forces infinitely different in power are forever acting on every atom, and its changes are the resultants of them all.

These ceaseless changes are purely mechanical, and mechanical laws produce their results absolutely without regard to future aims, absolutely indifferent to the quality of results, whether towards evolution or degeneration. For that reason, I repeat that any dogmatic assumption of evolution as a law of nature is unscientific. Of a million changes, a few may act in so strengthening the energy of the primary and permanent characters that they will resist the deterrent or subversive action of other forces So far as we know, this is mere chance. Purely mechanical forces decide the progress of a species or its extinction. Beyond such mechanical, mathematical laws, natural science has no right to go.

In conclusion, I would say a few words in reference to "sports," a topic introduced by the last speaker. These sudden and extensive changes received the careful attention of Darwin, who in his work on the *Domestication of Animals and Plants,* refers to it by the term "spontaneous variation . . . ." He pointed out that in some cases it is extraordinarily great and also permanent, as in the instance of the niata cattle in La Plata. In the vegetable world, Mr. Meehan has illustrated this form of change by numerous and striking examples. The last speaker mentioned that the lines of species had not been traced through sports. I would call attention to the obvious fact that the origin of what are called specific peculiarities from a sport would be likely to cause the scientific investigator to lose the trail at that point. Darwin says that nothing but the record would reconcile us to believing that such sports as some he describes issued from the species to which they belong.

How unconsidered then is the remark of the last speaker in reference to those who have suggested that man himself may have owed his specific peculiarity to such an origin ! There is nothing impossible in this, nothing incredible, nothing absurd. When our ancestors ascended from the plane of the beast to that of reasoning intelligence, a part of the path may have been won by one of those bounds which have been called saltatory evolution. There is nothing in this contrary to either theory or observation. It is supported by both ; and having once gained that higher plane, they would not willingly have forfeited its advantages.

Further remarks by Prof. L. H. Bailey :

Dr. Brinton has quoted me as saying, "From beginning to finish of creation, evolution is true." He quoted me correctly. That is my own conviction. I have no proof. I have no proof that the sun will rise to-morrow. But the greater the collection of facts and of data which we make respecting the evolution of the world in the past, the more are the changes seen to be continuous and gradual ; and it seems to me that if evolution has taught us anything it has been to show that there is a law of evolution, continuous throughout time. I believe, myself, that evolution is true from beginning to finish of creation ; and if we could not prophesy that our race has nobler possibilities for the future I should lose my zest to live.

Spontaneous variations are not necessarily sports in the sense in which I refer to them. Sports are those forms of variation which appear to lie outside the general or customary type of variation of the species—or phylum—with which we are dealing. They are those forms which are so unusual as to be ordinarily considered to be a taxonomic variety or division or subspecies. The causes of sports are unknown to us, as are also the causes of all spontaneous differences which may be of much less moment. The fact that Darwin dwelt upon the origin of sports in domestic animals is a matter which I discussed in my paper and, I believe, it is the chief line of effort in which man's work differs from nature's—the fact that he does save the sports and breed them up. I have no evidence that nature does the same ; and so far as the plant creation is concerned, I am more and more convinced that sports have had but comparatively small influence upon the phylogenies of our present types.

I wish to add just one word in reference to a matter which Prof. Conklin introduced. He took issue with Prof. Cope with respect to the doctrine of natural selection and the notion that Darwin did not attempt to account for variation. The doctrine of natural selection itself does not account for variation. It has been the misfortune of Darwin's writings that his doctrine of natural selection has been so emphasized as to overshadow everything else which he did. Amongst the causes of variability which Darwin enumerates are external stimuli, soil, weather, food, climate and other impinging factors ; so that Darwin conceived the idea that impinging stimuli were the causes of variations which, when they have arisen, have been bred up by natural selection.